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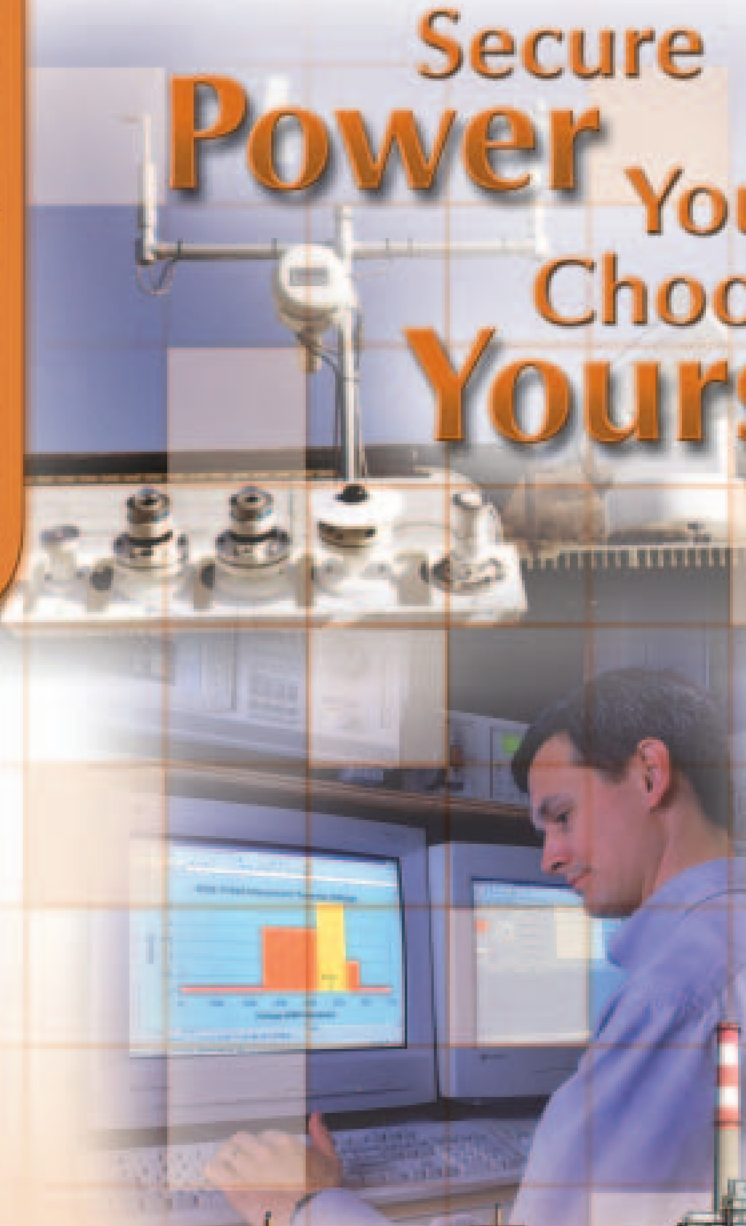
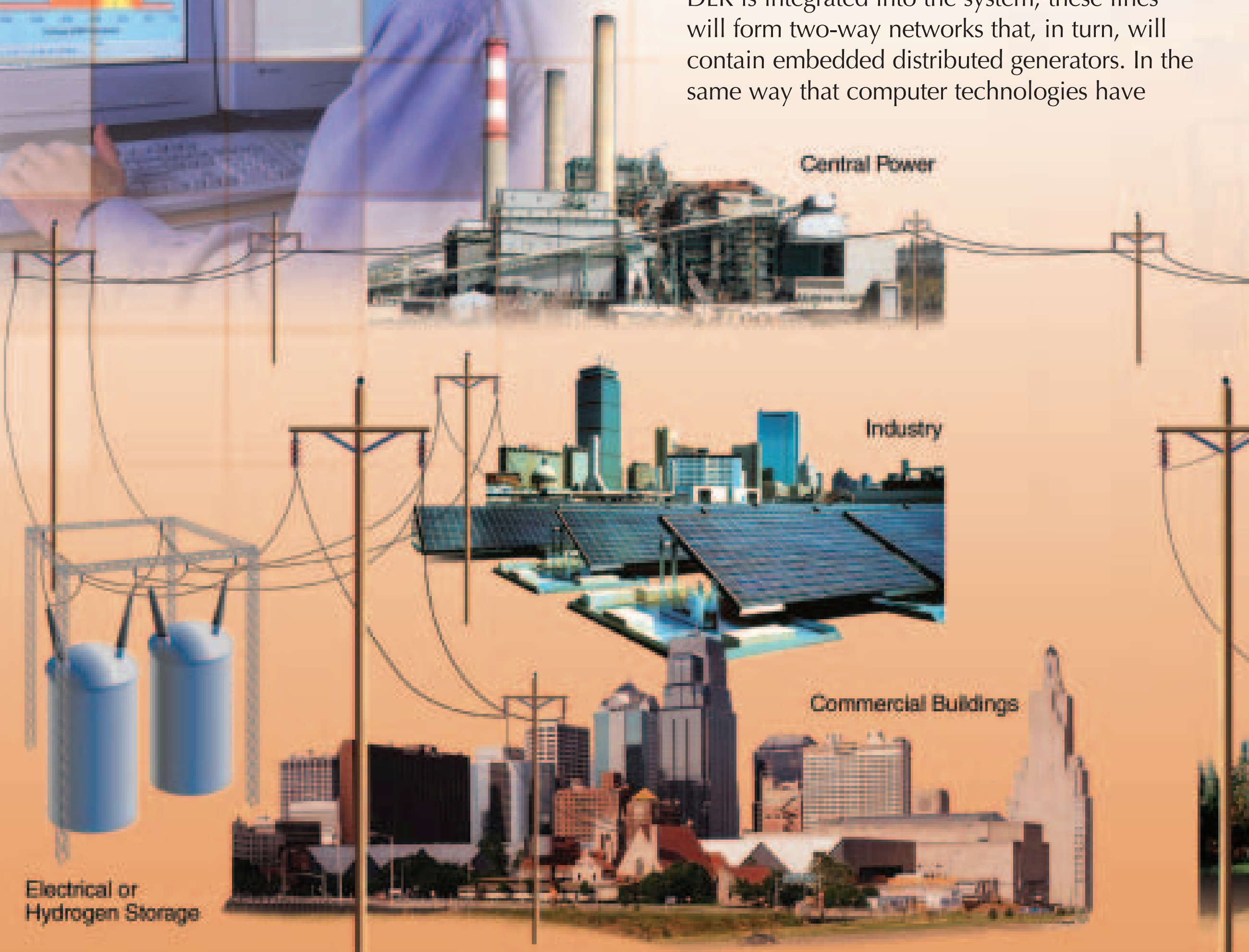
Secure Power You Choose Yourself



What IS *distributed energy resources*, or DER? The term refers to modular power generators that can be combined with energy management in storage to improve the electricity delivery system. In the future, DER will be the umbrella that connects exciting new technologies—fuel cells, building-integrated photovoltaics, and microturbines—together into power-generating packages that are located at your business or in your community. But, according to Dick DeBlasio, NREL's DER technology manager, "DER refers as much to the way that people will relate to energy—the way it will be distributed to your home, office, or school—as to the way the electricity is generated." DER is the way electricity will work in the future, but it is also the way we're going to make the transition to a more secure energy future, where businesses, hospitals, and schools can still operate even in emergencies and when the power grid is down.

Changing the Way We Grid

When you flip on a light at home today, electricity comes to you from the power grid—a giant system of distribution and transmission lines that radiate out from large power generation plants to send electricity to where we need it. Increasingly, as DER is integrated into the system, these lines will form two-way networks that, in turn, will contain embedded distributed generators. In the same way that computer technologies have

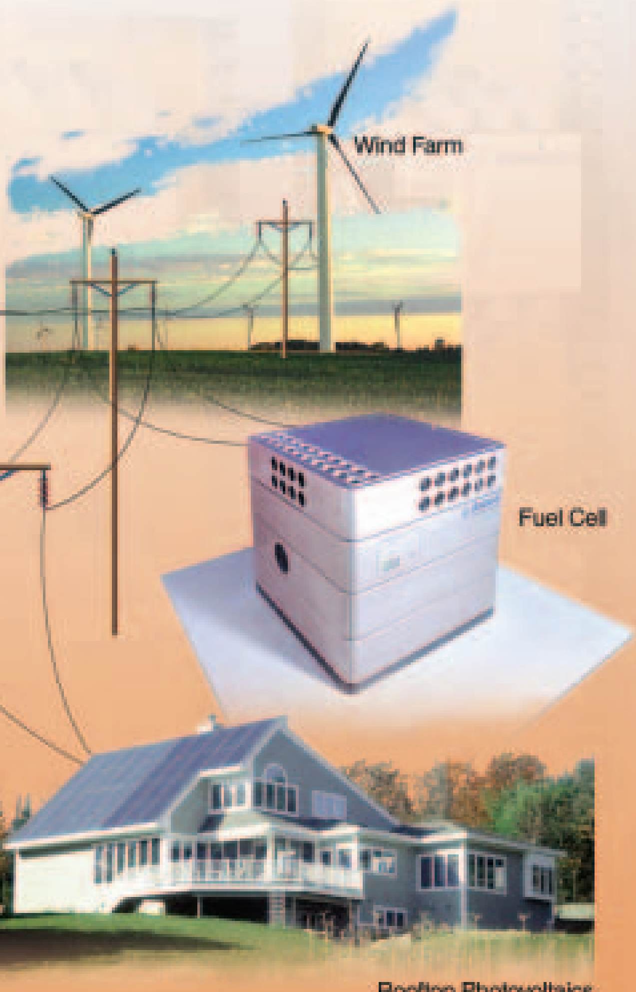


In the future, distributed energy resources will be the way energy works—connecting exciting new technologies into power-generating packages located at your business or in your community. In addition to central power plants, distributed energy means that a variety of electricity sources are distributed close to where they will be used, allowing for more efficient use of heat that is "wasted" at power plants today. It also provides greater security, spreading out sources of electricity so that operations can continue even if one source is not operational.

gone from mainframes to smaller computers networked together, the future power system will be decentralized. Smaller "mini-grids" containing their own generators will be distributed throughout the larger system, closer to where the electricity can be used.

These mini-grids can be as simple as one or two small generators feeding electricity to your business or back to the power grid if you're not using it. Or, they can be much more complicated—containing several types of generators, such as fuel cells that convert hydrogen into electricity, photovoltaics, or wind turbines, along with biomass or fossil-fuel generators for backup and energy storage systems—all networked together and controlled by computers that manage the power systems.

According to Tony Schaffhauser, NREL's DER center director, DER is really about flexibility and choice. "DER provides people with a greater choice of sources, including more control over what environmental effects the electricity they use will have," he says.



Making Power Reliable

DER is about flexibility and choice—and more. Moving toward an electricity model based on integrating distributed energy resources into the energy infrastructure has a variety of benefits. For one thing, having many power generators connected to a grid in a distributed fashion could greatly increase reliability—with a smart, well-designed distributed energy network, power would always be available (or at least 99.99999% of the time). Blackouts (which are caused primarily by failures in distribution lines) and rolling brownouts may even become a thing of the past.

Second, the quality of the power provided has a potential to become much better and more stable. As a result, there would be far fewer voltage surges, spikes, and sags. This could be important to the modern business community, much of which is run by digital technology and is very sensitive to variations in power

The Distributed Resource

Distributed energy resources does not just refer to distributed generation of power. It also refers to the fact that much of the natural resources that can be used to provide the energy that generates the electricity also is distributed. This includes wind energy, geothermal energy, hydropower, biomass, and sunshine (or solar radiation). In making decisions on where or whether to locate a generator dependent on these resources, it is important to know their spatial distribution, intensity, availability, and other characteristics. NREL scientists have long been modeling, measuring, and characterizing these resources. In particular, throughout its existence, NREL has steadily built a world-renowned reputation for its research in solar radiation, especially in measuring and modeling this resource.

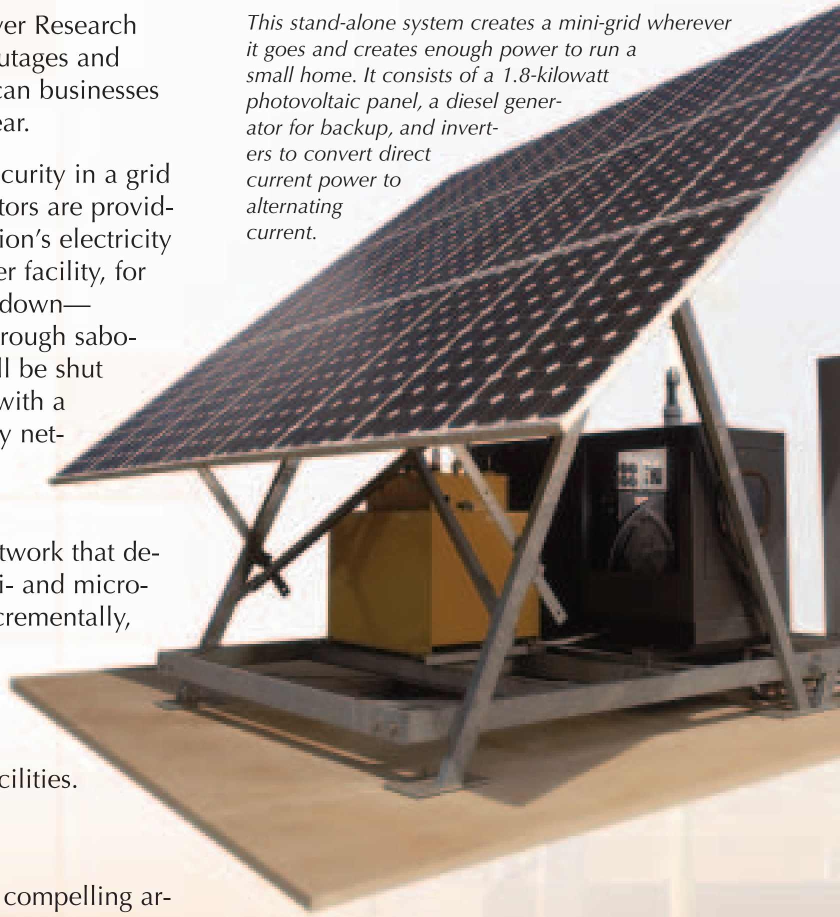
At the center of this reputation is NREL's Solar Radiation Research Laboratory. This unique research facility continually measures and monitors solar radiation and other meteorological data and disseminates the information to government, industry, academic, and international laboratories and agencies. The data that the laboratory measures includes global, diffuse, and direct-normal irradiance, ultraviolet radiation, infrared radiation from the Earth's surface, atmospheric aerosols, wind speed and direction, temperature, barometric pressure, relative humidity, and more. These data may not only be used for testing systems that convert solar energy to electricity, but also for climate-change studies, for research on weather and the atmosphere, and more.

A researcher adjusts an absolute cavity radiometer at NREL's Solar Radiation Research Laboratory. Absolute cavity radiometers are used to make very accurate measurements of solar irradiance and provide the reference from which other radiometers are calibrated.

quality. In fact, the Electric Power Research Institute estimates that power outages and poor power quality cost American businesses more than $100 billion each year.

Third, there is greater energy security in a grid network in which many generators are providing the electricity. If all of a region's electricity is supplied by one central power facility, for example, and that facility goes down—whether by natural means or through sabotage—then the entire region will be shut down. This would not happen with a well-designed distributed energy network, which provides inherent redundancy and safety.

DER also benefits utilities. A network that depends on a wide variety of mini- and micro-generators can add capacity incrementally, when and where it is needed. Such a network can avoid the expensive financial and time commitment demanded by the construction of large, central facilities.



This stand-alone system creates a mini-grid wherever it goes and creates enough power to run a small home. It consists of a 1.8-kilowatt photovoltaic panel, a diesel generator for backup, and inverters to convert direct current power to alternating current.

Using All the Heat

But efficiency may be the most compelling argument for distributed energy resources. Traditional power generation plants burn coal or gas. But only about one-third of the primary energy used is captured and converted to electricity. Then, as much as another 10% can be lost through transmission and distribution of the electricity. Since the point of DER, on the other hand, is to generate electricity close to where it is to be used, you can minimize losses due to transmission or distribution. Plus, heat that is traditionally "wasted" can be converted to power in other ways. Using waste heat efficiently, a micro-grid at your home will power your appliances; heat, cool, and adjust humidity levels in your home; and heat your water. In industrial settings, waste heat will power industrial processes.

Microturbines are representative of just one of the many kinds of distributed power generators that are ideal for use in a distributed network. Microturbines, which can be powered by natural gas or biofuels, provide a reliable source of electricity and heat for commercial businesses and industries.

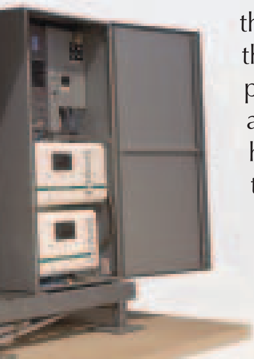
Researchers are working on additional and more effective ways to use that waste heat and make power generation more effective. As we find ways to be more efficient, as much as 60% of the power used to generate electricity will be captured.

Making the Rules

As the brave new world of creating our own electricity evolves, we need to think strategically about the rules that will govern its use. Like codes and standards governing the way buildings are made or commerce is conducted, standards for the way that people can connect into the power grid, how they can send electricity back to the grid, and rules governing the way that utilities relate to these mini-grids are critical. Right now, businesses that install photovoltaic systems and try to tie in to the power grid face different procedures with different utilities, and states and local governments also have different rules.

Navigating the process can be frustrating and lengthy.

But for two years now, a national group of almost 300 members of the Institute of Electrical and Electronics Engineers (IEEE)—representatives from utilities, electricity producers, manufacturers, laboratories, and consulting groups—have been developing technical standards to make the process more consistent. NREL's Dick DeBlasio, chair of the IEEE working group, says that once the group has approved the standards, state and federal regulators will have the option of adopting them. "Right now there are hundreds, if not thousands, of utility rules for connecting to the grid," he says. "The standards we are developing will, as they are adopted by utilities and regulatory commissions, level the playing field for distributed resources and enable them to compete in the marketplace."



At the same time, from the regulatory perspective, state and local governments are also trying to address the challenges of bringing about a distributed energy generation future. Gary Nakarado, NREL's DER regulatory liaison, is working with regulators to make changes in the way that regulations are structured—moving to a different model that can accommodate more customer choice and more power providers. "The traditional regulatory model is turned on its head by distributed generation," Nakarado says. "We need to encourage policy makers to ask the important questions, like 'What's in the public interest?' because there are so many new tools and technologies available."

Pulling It All Together

The full integration of renewable energy resources and distributed generation into the nation's energy infrastructure will be a long-term process that will involve research, technology, negotiations, and cooperation on many levels across the United States. But such an integration will liberate our dependence on traditional fuel sources. And it will provide a reliable, secure, and flexible system of powering America.

A researcher monitors the control panel for a simulated utility grid at NREL's Distributed Energy Resources Test Facility. Using the control panel, researchers can adjust voltage, frequencies, loads, and a variety of other parameters to determine how the network may work under different conditions.

Electricity Soup

The Distributed Energy Resources Test Facility looks like a mass of electric switches, panels, and lines connecting large machines together. That's exactly what it is—the facility, which is the only one of its kind, tests how distributed generation sources connect and work together.

At the facility, generation sources such as a 30-kW microturbine, 60- or 100-kW wind turbines, various-sized diesel generators, and a 1.8-kW photovoltaics panel are connected to a 200-kW "grid"—simulating a utility. This allows researchers to test how each of the sources work together and how they interact.

A lightning-surge simulator tests what happens to the individual sources and the whole system during adverse weather conditions, and the grid can also be turned off to simulate emergency situations when the electric grid is down. Grid-simulator controls allow researchers to adjust the voltage and frequency of electricity moving in the grid to simulate sags and surges on the distribution system—similar to variations in the real power grid and distribution systems that result in blackouts or brownouts. Using an electric-load simulator, researchers can see how the systems work under different use patterns—up to 165 kW of load.

This kind of work requires a high-speed data acquisition system—and the facility has one that samples at 5 million samples per second. Collecting data that quickly allows researchers to monitor high-speed interconnections between the generation sources and to record electrical faults and disturbances.

The test facility will help determine how reliable distributed power systems are, provide research data to use when developing interconnection standards, and help understand how complex energy systems can be integrated together. Researchers can evaluate moment-by-moment dynamics of distributed power systems, gather data on long-term performance, and demonstrate new design concepts.

A new, larger, energy-efficient test facility is under design and is expected to open by 2005. The 10,000-square-foot facility will increase testing capacity to up to 1 MW of generation.